

IN THE CLAIMS:

The following listing of claims will replace all prior versions, and listings of claims in the application:

Listing of Claims:

1. (*Currently Amended*) A three dimensional inspection method for inspecting ball grid array devices having a plurality of balls, wherein the ball grid array device is positioned in an optical system, the inspection method ~~comprising the steps of:~~
comprising:

a) illuminating at least one ball on the ball array device
using a fixed illumination system;

b) disposing a single sensor, a first optical element and a second optical element in relation to the ball grid array device so that the sensor obtains at least two differing views of the at least one ball, the sensor providing ~~an~~ output representing the at least two differing views; and

e) processing the output using a triangulation method to calculate a three dimensional position of the at least one ball with reference to a pre-calculated calibration plane.

2. (*Original*) The three dimensional inspection method of claim 1 wherein the pre-calculated calibration plane comprises a coordinate system having X, Y and Z axes and wherein an X measurement value is proportional to a Z measurement value.

3. *(Original)* The three dimensional inspection method of claim 1 wherein the pre-calculated calibration plane comprises a coordinate system having X, Y and Z axes and wherein an XY measurement value is proportional to a Z measurement value.

4. *(Original)* The three dimensional inspection method of claim 1 wherein the pre-calculated calibration plane comprises a coordinate system having X, Y and Z axes and wherein a Y measurement value is proportional to a Z measurement value.

5. *(Original)* The three dimensional inspection method of claim 1 wherein the triangulation method is based on determining a center of the ball in a first view and determining a ball top location in a second view.

6. *(Original)* The three dimensional inspection method of claim 1 wherein the pre-calculated calibration plane is defined by measuring a calibration pattern.

7. *(Original)* The three dimensional inspection method of claim 1 wherein the second optical element comprises a mirror.

8. *(Original)* The three dimensional inspection method of claim 1 wherein the second optical element comprises a prism.

9. *(Original)* The three dimensional inspection method of

claim 1 wherein one of the at least two differing views is obtained at a low angle of view.

10. *(Original)* The three dimensional inspection method of claim 1 wherein the sensor and the second optical element are positioned to receive light from different angles relative to the calibration plane.

11. *(Original)* The three dimensional inspection method of claim 1 wherein the sensor comprises a charged coupled device array.

12. *(Original)* The three dimensional inspection method of claim 1 wherein the sensor comprises a complementary metal oxide semiconductor device array.

13. *(Currently Amended)* The three dimensional inspection method of claim 1 wherein the processing ~~step further~~ includes ~~the step of~~ applying grayscale edge detection to locate ball positions.

14. *(Currently Amended)* The three dimensional inspection method of claim 1 wherein the processing ~~step further~~ includes ~~the step of~~ applying threshold analysis.

15. *(Original)* The three dimensional inspection method of

claim 1 wherein the first optical element comprises a lens.

16. *(Original)* The three dimensional inspection method of claim 1 wherein the first optical element comprises a pin-hole lens.

17. *(Original)* The three dimensional inspection method of claim 1 wherein the first optical element comprises a plurality of lens elements.

18. *(Original)* The three dimensional inspection method of claim 1 wherein the first optical element comprises a telecentric lens.

Claim 19 *(Canceled)*

20. *(Currently Amended)* The three dimensional inspection method of claim 1 wherein the ball grid array devices comprise bump on wafer devices.

21. *(Currently Amended)* The three dimensional inspection method of claim 1 wherein ~~the step of~~ processing the output is carried out on a personal computer.

22. *(Original)* The three dimensional inspection method of claim 1 wherein the sensor includes a solid state sensor array.

23. (*Original*) The three dimensional inspection method of claim 1 wherein one of the views comprises a segment having a crescent shape.

24. (*Currently Amended*) A three dimensional inspection method for ball grid array devices having a plurality of balls, the method ~~comprising the steps of:~~ comprising:

a) illuminating the ball array device using a fixed illumination system;

b) disposing a single sensor to receive light at a first angle relative to the ball grid array device;

c) positioning a first optical element to transmit light to the sensor, where the sensor obtains a first view of the ball grid array device;

d) disposing a second optical element to receive light at a second angle different from the first angle and to transmit a second view of the ball grid array device to the sensor;

e) transmitting image information from the sensor; and

f) processing the image information by applying triangulation calculations to measurements of the image information so as to calculate a three dimensional position of at least one ball with reference to a pre-calculated calibration plane.

25. *(Original)* The three dimensional inspection method of claim 24 wherein the calibration plane comprises a coordinate system having X, Y and Z axes and wherein an X measurement value is proportional to a Z measurement value.

26. *(Original)* The three dimensional inspection method of claim 24 wherein the calibration plane comprises a coordinate system having X, Y and Z axes and wherein an XY measurement value is proportional to a Z measurement value.

27. *(Original)* The three dimensional inspection method of claim 24 wherein the calibration plane comprises a coordinate system having X, Y and Z axes and wherein a Y measurement value is proportional to a Z measurement value.

28. *(Original)* The three dimensional inspection method of claim 24 wherein the pre-calculated calibration plane is defined by measuring a calibration pattern.

29. *(Original)* The three dimensional inspection method of claim 24 wherein the second optical element comprises a mirror.

30. *(Original)* The three dimensional inspection method of claim 24 wherein the second optical element comprises a prism.

31. *(Currently Amended)* The three dimensional inspection

method of claim 24 wherein the ~~step of~~ illuminating comprises the ~~step of~~ illuminating with a ring light.

32. (*Currently Amended*) The three dimensional inspection method of claim 24 wherein the ~~step of~~ illuminating comprises the ~~step of~~ illuminating with a plurality of light emitting diodes.

33. (*Currently Amended*) The three dimensional inspection method of claim 24 wherein the ~~step of~~ illuminating comprises the ~~step of~~ illuminating with reflected light.

34. (*Original*) The three dimensional inspection method of claim 24 wherein the sensor comprises a charged coupled device array.

35. (*Original*) The three dimensional inspection method of claim 24 wherein the sensor comprises a complementary metal oxide semiconductor device array.

Claim 36 (*Canceled*)

37. (*Currently Amended*) The three dimensional inspection method of claim 24 wherein the ball grid array devices comprise bump on wafer devices.

38. (*Currently Amended*) The three dimensional inspection method of claim 24 wherein the processing ~~step further~~ includes

~~the step of~~ applying grayscale edge detection to locate ball positions.

39. (*Currently Amended*) The three dimensional inspection method of claim 24 wherein the processing ~~step further~~ includes ~~the step of~~ applying threshold analysis.

40. (*Original*) The three dimensional inspection method of claim 24 wherein the first optical element comprises a lens.

41. (*Original*) The three dimensional inspection method of claim 24 wherein the first optical element comprises a pin-hole lens.

42. (*Original*) The three dimensional inspection method of claim 24 wherein the first optical element comprises a plurality of lens elements.

43. (*Original*) The three dimensional inspection method of claim 24 wherein the first optical element comprises a telecentric lens.

Claim 44 (*Canceled*)

45. (*Original*) The three dimensional inspection method of claim 24 wherein the sensor includes a solid state sensor array.

46. (*Currently Amended*) The three dimensional inspection method of claim 24 wherein the ~~step of~~ processing is carried out on a personal computer.

47. (*Original*) The three dimensional inspection method of claim 24 wherein the second optical element reflects a view to the sensor where at least one ball of the ball array device exhibits a crescent shape.

48. (*Currently Amended*) A three dimensional inspection method for ball grid array devices having a plurality of balls, the method ~~comprising the steps of:~~ comprising:

a) illuminating a ball grid array device using a fixed illumination system;

b) disposing a single sensor to receive light at a first angle relative to the ball grid array device, wherein the sensor includes a solid state sensor array;

c) disposing a first optical element to transmit light to the sensor, where the sensor obtains a first view of the ball grid array device;

d) disposing a second optical element to receive light at a second angle different from the first angle, and to transfer a second view of the ball grid array device to the sensor;

e) transmitting image information representing the first

view and the second view; and

~~f~~ processing the image information by applying triangulation calculations to measurements of the image information so as to calculate a three dimensional position of at least one ball with reference to a precalculated calibration plane, wherein the calibration plane comprises a coordinate system having X, Y and Z axes, and wherein an X measurement value is proportional to a Z measurement value.

49. *(Original)* The three dimensional inspection method of claim 48 wherein an XY measurement value is proportional to a Z measurement value.

50. *(Original)* The three dimensional inspection method of claim 48 wherein a Y measurement value is proportional to a Z measurement value.

51. *(Original)* The three dimensional inspection method of claim 48 wherein the pre-calculated calibration plane is defined by measuring a calibration pattern.

52. *(Currently Amended)* The three dimensional inspection method of claim 48 wherein the processing ~~step further includes the step of~~ comprises applying grayscale edge detection to locate ball positions.

53. (*Currently Amended*) The three dimensional inspection method of claim 48 wherein the processing ~~step further~~ includes ~~the step of~~ applying threshold analysis.

54. (*Currently Amended*) The three dimensional inspection method of claim 48 wherein the ~~step of~~ illuminating comprises ~~the step of~~ illuminating with a plurality of light emitting diodes.

55. (*Currently Amended*) The three dimensional inspection method of claim 48 wherein ~~step of~~ illuminating comprises ~~the step of~~ illuminating with reflected light.

Claim 56 (*Canceled*)

57. (*Currently Amended*) The three dimensional inspection method of claim 48 wherein the ball grid array devices comprise bump on wafer devices.

58. (*Original*) The three dimensional inspection method of claim 48 wherein the solid state sensor array includes a charged coupled device array.

59. (*Original*) The three dimensional inspection method of claim 48 wherein the solid state sensor array includes a complementary metal oxide semiconductor array.

60. (*Original*) The three dimensional inspection method of

claim 48 wherein the second optical element comprises a mirror.

61. *(Original)* The three dimensional inspection method of claim 48 wherein the second optical element comprises a prism.

62. *(Original)* The three dimensional inspection method of claim 48 wherein the second view comprises a segment having a crescent shape.

63. *(Currently Amended)* The three dimensional inspection method of claim 48 wherein the image ~~acquisition method comprises~~ information representing the first view and the second view is acquired using a frame grabber.

64. *(Currently Amended)* The three dimensional inspection method of claim 48 wherein ~~the step of processing the output~~ image information is carried out on a personal computer.

65. *(Original)* The three dimensional inspection method of claim 48 wherein the first optical element comprises a lens.

66. *(Original)* The three dimensional inspection method of claim 48 wherein the first optical element comprises a pin-hole lens.

67. *(Original)* The three dimensional inspection method of claim 48 wherein the first optical element comprises a plurality

of lens elements.

68. (*Original*) The three dimensional inspection method of claim 48 wherein the first optical element comprises a telecentric lens.

69. (*Currently Amended*) A three dimensional inspection method for ball grid array devices having a plurality of balls, the method ~~comprising the steps of:~~ comprising:

a) measuring a calibration plate to determine a calibration plane;

b) illuminating a ball grid array device using a fixed illumination system;

c) disposing a single sensor to receive light at a first angle relative to the ball grid array device, wherein the sensor includes a solid state sensor array;

d) disposing a first optical element to transmit light to the sensor, where the sensor obtains a first view of the ball grid array device;

e) disposing a second optical element to receive light at a second angle different from the first angle, and to transfer a second view of the ball grid array device to the sensor;

f) transmitting image information representing the first view and the second view; and

g) processing the image information by applying triangulation calculations to measurements of the image information so as to calculate a three dimensional position of at least one ball with reference to the calibration plane, wherein the calibration plane comprises a coordinate system having X, Y and Z axes, and wherein an X measurement value is proportional to a Z measurement value.

70. (*Currently Amended*) A three dimensional inspection process for ball grid array devices having a plurality of balls, wherein the ball grid array device is positioned in a fixed optical system, the process ~~comprising the steps of:~~ comprising:

a) illuminating the ball grid array device using a fixed illumination system;

b) taking a first image of the ball grid array device with a single camera disposed in a fixed focus position relative to the ball grid array device to obtain a circular doughnut shape image from at least one ball;

c) taking a second image of the ball grid array device with an optical element disposed in a fixed focus position relative to the ball grid array device to transmit a side view image of the at least one ball to the camera; and

d) processing the first image and the second image using a triangulation method to calculate a three dimensional position of

the at least one ball with reference to a pre-calculated calibration plane.

71. *(Original)* The three dimensional inspection process of claim 70 wherein the second image comprises a segment having a crescent shape.

72. *(Original)* The three dimensional inspection process of claim 70 wherein the calibration plane comprises a coordinate system having X, Y and Z axes and wherein an X measurement value is proportional to a Z measurement value.

73. *(Original)* The three dimensional inspection process of claim 70 wherein the triangulation method to calculate a three dimensional position of the at least one ball is based on determining a center of the ball in the first image and determining a ball top location in the second image.

74. *(Currently Amended)* The three dimensional inspection process of claim 70 wherein the pre-calculated calibration plane is defined through ~~the step of~~ measuring a calibration pattern.

75. *(Original)* The three dimensional inspection process of claim 70 wherein the optical element comprises a mirror.

76. *(Original)* The three dimensional inspection process of

claim 70 wherein the second image is obtained at a low angle of view.

77. *(Original)* The three dimensional inspection process of claim 70 wherein the camera and the optical element are fixed at different angles relative to the calibration plane.

78. *(Original)* The three dimensional inspection process of claim 70 wherein the camera comprises a charged coupled device array.

79. *(Currently Amended)* The three dimensional inspection process of claim 70 wherein ~~the step of~~ processing the first image and the second image ~~further~~ comprises employing grayscale edge detection to locate ball positions.

80. *(Currently Amended)* The three dimensional inspection process of claim 70 wherein ~~the step of~~ illuminating the ball grid array device ~~further comprises employing~~ employs diffuse illumination.

Claim 81 *(Canceled)*

82. *(Currently Amended)* The three dimensional inspection process of claim 70 wherein the ball grid array devices comprise bump on wafer devices.

83. (*Currently Amended*) The three dimensional inspection process of claim 70 wherein the triangulation method uses state values derived from the ball grid array device.

84. (*Currently Amended*) The three dimensional inspection ~~process~~ method of claim 1 wherein the triangulation method uses state values derived from the ball grid array device.

85. (*Currently Amended*) The three dimensional inspection ~~process~~ method of claim 24 wherein the triangulation calculations use state values derived from the ball grid array device.

86. (*Currently Amended*) The three dimensional inspection ~~process~~ method of claim 48 wherein the triangulation calculations use state values derived from the ball grid array device.

87. (*Currently Amended*) The three dimensional inspection ~~method~~ process of claim 70 wherein the processing ~~step further~~ includes ~~the step of~~ applying threshold analysis.

88. (*Currently Amended*) The three dimensional inspection ~~method~~ process of claim 70 wherein the sensor comprises a charged coupled device array.

89. (*New*) The three dimensional inspection method of claim 1, wherein the at least one ball on the ball grid array device

being inspected comprises a contact.

90. (New) The three dimensional inspection method of claim 1, wherein the at least one ball on the ball grid array device being inspected comprises a pin.

91. (New) The three dimensional inspection method of claim 1, wherein the at least one ball on the ball grid array device being inspected is selected from the group consisting of: bump contact, ball contact, pad, and pedestal.

92. (New) The three dimensional inspection method of claim 1, wherein the two different views of the at least one ball are obtained in a single image.

93. (New) The three dimensional inspection method of claim 1, wherein the two different views of the at least one ball are each obtained in a separate image.

94. (New) The three dimensional inspection method of claim 24, wherein the at least one ball on the ball grid array device being inspected comprises a contact.

95. (New) The three dimensional inspection method of claim 24, wherein the at least one ball on the ball grid array device being inspected comprises a pin.

96. (New) The three dimensional inspection method of claim 24, wherein the at least one ball on the ball grid array device being inspected is selected from the group consisting of: bump contact, ball contact, pad, and pedestal.

97. (New) The three dimensional inspection method of claim 24, wherein the first and second views of the at least one ball are obtained in a single image.

98. (New) The three dimensional inspection method of claim 24, wherein the first and second views of the at least one ball are each obtained in a separate image.

99. (New) The three dimensional inspection method of claim 32, wherein at least two of the plurality of light emitting diodes are spectrally diverse from one another.

100. (New) The three dimensional inspection method of claim 48, wherein the at least one ball on the ball grid array device being inspected comprises a contact.

101. (New) The three dimensional inspection method of claim 48, wherein the at least one ball on the ball grid array device being inspected comprises a pin.

102. (New) The three dimensional inspection method of claim

48, wherein the at least one ball on the ball grid array device being inspected is selected from the group consisting of: bump contact, ball contact, pad, and pedestal.

103. (New) The three dimensional inspection method of claim 48, wherein the image information representing the first view and the second view comprise a single image.

104. (New) The three dimensional inspection method of claim 48, wherein the image information representing the first view and the second view each comprise a separate image.

105. (New) The three dimensional inspection method of claim 54, wherein at least two of the plurality of light emitting diodes are spectrally diverse from one another.

106. (New) The three dimensional inspection process of claim 70, wherein the at least one ball on the ball grid array device being inspected comprises a contact.

107. (New) The three dimensional inspection process of claim 70, wherein the at least one ball on the ball grid array device being inspected comprises a pin.

108. (New) The three dimensional inspection process of claim 70, wherein the at least one ball on the ball grid array

device being inspected is selected from the group consisting of:
bump contact, ball contact, pad, and pedestal.

109. (New) The three dimensional inspection process of claim 70, wherein the circular doughnut shape image and the side view image comprise a single image.

110. (New) The three dimensional inspection process of claim 70, wherein the circular doughnut shape image and the side view image each comprise a separate image.